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The effect of biofertilization and organic fertilization and the interaction between them on the yield characteristics and components of the mung bean plant *Vigna radiata* L.

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A field experiment was conducted in the fall season of 2022 in the village of Aday in Baquba District - Diyala Governorate, on the mash plant. Vigna radaita a local vegetable cultivar in clay soil in order to study the effect of biofertilization with *Azotobacter chroococcum* and Mycorhiza fungi (*Glomus mosseae*) and organic fertilization with humic acid and the interaction between them on the vegetative characteristics of the mung bean plant. The experiment was carried out according to the randomized complete block design (R.C.B.D) and with three replications. It included two factors, the first was biological fertilization, which included four treatments, namely (without addition, the addition of Azotobacter, the addition of Mycorrhiza, and the addition of Azotobacter + Mycorrhiza) and the second factor was organic fertilization, which included four concentrations of humic acid 0 and 3 And 6 and 9 ml.l^{-1}. The following are the most important results that were reached:
- The superiority of biofertilization treatment by adding Azotobacter and Mycorrhizae in the yield and its components, such as the number of pods, the weight of 1000 seeds, the yield of one plant, the overall yield, obtained, Azolobacter and mycorrhizae were introduced to the biofertilization process., 130.83 pods.plant^{-1}, 29.26 gm., 35.57 g.m. plant^{-1}, 2341.08 kg.h^{-1}.
- The treatment of organic fertilization with humic acid at a concentration of 9 ml.L^{-1} was superior in giving it the highest mean in the number of pods, the weight of 1000 seeds, yield per plant, overall yield, which reached 127.14 pod.plant^{-1}, 27.76 gm., 36.2 gm. plant^{-1}, 2221.2 kg.h^{-1}.
Keyword: Biofertilization, azotobacter, organic fertilization, humic acid, mycorrhizal, *Vigna radiata*.

INTRODUCTION

The mung bean *Vigna radiata* L. One of the summer crops in the Fabaceae family of legumes, which can withstand both drought and hot temperatures. It is grown throughout most of Iraq's governorates, with an estimated 25308 dunums of mash-producing land and an annual production rate of 8944 tons. dunums^{-1} (Agricultural Statistics Directorate, 2019). Mung bean seeds, which are indigenous to the Indian subcontinent and have a protein content that ranges from 19–29%, are utilized as a low-cost source of protein. Lysine, an amino acid, is abundant in it. Mash contains isoflavones as well as a lot of vitamins, minerals, and carbs. Mash flour is also used to make bread and desserts, and leftover plant material is fed to animals as food. Since it can fix nitrogen while consuming minimal water and producing a significant financial gain, it is also regarded as a green fertilizer for the soil (Abdullah *et al.*, 2009 and Chadh K, 2010). Vital is a substance that contains living resources for microorganisms that are placed on seeds, soil, or with roots for the purpose of boosting plant growth through primary nutrients that activate critical activities in the plant, such as fixing nitrogen and enabling phosphorus. Examples of such substances include Rhizobium and Azotobacter. (Talekar *et al.*, 2021). Azotobacters have advantageous impacts for plants, but their abundance is influenced by a number of variables, such as the physical and chemical composition of the soil (such as temperature, organic matter, pH, and soil moisture). The amount varies according to soil depth. (Bhat *et al.*, 2011). In order to encourage fungal growth and reduce plant disease, biofertilizers produce antibiotics. This reduces the need for conventional pesticides. The use of natural materials like biofertilizers and organic fertilizers, which are supplementary to mineral fertilizers, has increased as a result of the global shift toward clean farming approaches (Al-Zoghbi *et al.*, 2007; Al-Wahaibi, 2008). Some plants have a relationship

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with mycorrhiza fungi that has been referred to because both the fungus and the plant profit from it, it is referred to be a mutualistic symbiosis. It also significantly contributes to the plant's uptake of nutrients like phosphorus and a number of other crucial minerals, as well as protecting plants from soil infections (Smith and Read, 2008). One of the modern agricultural trends that employs organic natural resources to grow crops and increase their production rather than industrial chemicals that are bad for people's health and the environment is the usage of humic acid, which is one of the components of organic matter (Taha, 2007). When added to soil, humic acid offers a number of advantages, such as improving the effectiveness of chemical use, lowering the amount used, conserving soil health and environmental safety, keeping the balance of nutrients, reducing stress, and all of the above. (Daniel *et al.,* 2018). Due to the fact that humic acid contains a number of elements crucial for plant growth, it is regarded as one of the most significant humic organic acids (Berger and Gutjahr, 2021). The goal of the study is to studying the effect of biofertilization with azotobacter and mycorrhiza fungi on the yield of mung bean. Study of the effect of organic fertilization with humic acid on the yield of mung bean. Finding the best interaction between azotobacter, mycorrhizal fungus and humic acid, which affects the increase of the yield of the mung bean plant.

MATERIALS AND METHODS

Experimental site: In the summer of 2022, a field experiment on the mung bean crop on clay soil was conducted Aday hamlet, which is located approximately 5 kilometers to the west of Baquba district in the Diyala Governorate's Baquba district, in one of the agricultural fields.

Soil analysis: Before planting random selections of the field's soil were taken from various locations for analysis to determine some of the soil's chemical and physical characteristics. This analysis was done as stated in Table 1, in the laboratories of the Directorate of Agriculture in Baqubah.

Table 1. Some physical and chemical characteristics of the study soil before planting.

T	Analysis type	Value	Unit	Notes
1	Salinity Ec	2.51	ds m^{-1}	
2	Soil pH reaction	7.45		
3	Organic matter O.M	19.9	gm. kg^{-1}	
4	Calcium carbonate	270	gm. kg^{-1}	
5	potassium	170	mg kg^{-1}	
6	phosphorous	8.6	mg kg^{-1}	
7	tissue	Clay 445.6 Silt 318.4 Sand 236.0	gm. kg^{-1}	The texture clayey
8	nitrogen	15.07	mg. kg^{-1}	

A factorial experiment with two factors was carried out according to the Randomized Complete Block Design (R.C.B.D.), with three replications, to study the effect of organic and biological fertilization and the interaction between them on the growth and yield of the mung bean plant. The distance between one line and another is 50 cm, at a rate of 4 lines in each experimental unit, and four plants in each line, and the distance is 1 m between experimental units and 2 m between replicates. The number of experimental units in each replicate = 16 experimental units, and thus the total number of experimental units equals 48 experimental units, with a plant density of 80,000 plants. The experimental treatments included two factors, the first factor is biological fertilization, which included four treatments, namely: without addition, the addition of Azotobacter, the addition of Mycorrhiza, and the addition of Azotobacter + Mycorrhizae. The second factor was the organic fertilization, which included four concentrations of humic acid 0, 3, 6, and 9 $gm.l^{-1}$. The study used a locally grown species of seeds called Vigna radiate L. Azotobacter chroococcum was collected from the Department of Agricultural Research of the Ministry of Al-Zafaraniya's science and technology section as a local isolate of the bacterial inoculum. Additionally, the mycorrhizal fungus vaccine was used. Mosseae Glomus The inoculum, which was used in the study, was acquired from the Department of Agricultural Research, the Al-Zafaraniya and the Ministry of Science and Technology. It was composed of (spores + infected roots + soil with moss).

Parameters recorded

1-Number of pods (pod. plant^{-1}): The number of pods was calculated from all the plants taken for the study and the average was extracted on the basis of one plant.

2-Weight of 1000 seeds (g): 1000 seeds were randomly selected from the harvested batch, mixed, and weighed using a precise scale.

3-Yield per plant (gm. plants^{-1}): It was calculated by calculating the plant yield in five plants from the two middle lines of each experimental unit, then it was weighed using the sensitive balance, and the average yield of one plant was extracted.

4- The total plant yield (kg.h^{-1}): After calculating the yield of one plant, the total yield was calculated through the following equation:

Total yield ($kg.ha^{-1}$) = average yield per plant (gm. $plant^{-1}$) x plant density

statistical analysis: Comparing the averages using the 0.05 was set as the threshold for probability, and the data's statistical analysis was performed utilizing a factorial experiment with the SAS system under it uses a randomized whole block design (RCBD) (Al-Sahoki and Wahib, 1990).

RESULTS AND DISCUSSION

The effect of organic and biological fertilization and the

interaction between them on the quantitative and qualitative traits of mung bean

Number of pods (pod. plant^{-1}): The results of Table 2 indicate that there are significant differences in the characteristic of the number of pods when biofertilizing, as the biofertilization treatment with Azotobacter and Mycorrhizae gave the highest mean of 130.83 pods.plant^{-1} compared to the non-fertilization treatment, which amounted to 99.15 pods.plant^{-1}, with an increase of 31.95%. The reason for this is that Azotobacter and Mycorrhiza form a binary system that supplies the plant with phosphorus and nitrogen, in addition to the root nodule bacteria increasing the plant's uptake of nitrogen by the mycorrhizal fungi (Barea *et al.*, 1988), and the fungus also transfers the phosphorus element to the plant (Mosse and Hayman, 1980). This is consistent with the results of (Al-Burki, 2020). As for the organic fertilization, the fertilization with humic acid resulted in significant differences. The treatment of fertilization with humic acid at a concentration of 9 gm.l^{-1} gave the highest mean of 127.14 pods.plant-1 compared to the treatment of no fertilization, which amounted to 106.93 pods.plant^{-1}, with a percentage An increase of 18.9%, and the reason for this is due to the fact that humic acid has a role in encouraging the absorption of nutrients by increasing the permeability of cell membranes and stimulating enzymatic reactions, which work to increase vegetative growth, which leads to an increase in carbohydrates made by the leaf and thus its transfer to the fruiting parts, including a number Pods in plants (Abbas, 2013). Also, humic acid activates the growth of the vegetative and root system of the plant as well as revitalizing the organisms in the soil and increases the effectiveness of the absorption of nutrients and improves the quality of the crop and increases the amount of crop production (Rafiq and Al-Jubouri, 2020).

Weight of 1000 seeds (gm): The results of Table 3 indicate that there are significant differences in the weight of 1000 seeds when biofertilizing, as the biofertilization treatment with mycorrhiza fungi gave the highest average, reaching 35.57 gm, compared to no fertilization, 31.27 gm, with an increase of 13.75%. Providing the plant with nitrogen in sufficient quantity, which was reflected in the improvement of plant growth, which affected the number of pods, and the weight of 1000 seeds of the mung bean crop (Bhat *et al.*, 2011), as well as the efficiency of the mycorrhizal inoculum used, which led to an increase in the readiness to absorb elements, especially phosphorus (Hazarika *et al.*, 2000; Al-Mufti, 2004). As for organic fertilization, the treatment of humic acid at a concentration of 9 gm.l^{-1} gave the highest average of 36.20 gm, compared to no fertilization, which amounted to 31.74 gm, with an increase of 14.05%. Cell division and cell elongation, which led to an increase in the manufacture of carbohydrates in the leaves and then transferred to the fruits and thus increased the weight of the seeds (Shafeek *et al.*, 2013; Abead *et al.*, 2018).

***Yield per plant (g. plant^{-1})*:** The results of Table 4 indicate that there are significant differences in the yield of one plant when biofertilizing, as the biofertilization treatment with Azotobacter and Mycorrhizae gave the highest mean of

Table 2. The effect of biological and organic fertilization and the interaction between them on the number of pods of the mung bean (pod.plant^{-1}).

Biofertilization	**Organic fertilization (humic acid) gm.L^{-1}**				**average**
	0	**3**	**6**	**9**	
control	78.03	102.23	105.50	110.83	99.15
Azotobacter	111.43	118.43	120.73	123.26	118.46
Mycorrhiza	115.53	120.20	127.60	130.53	123.46
Azotobacter + Mycorrhiza	122.73	126.06	130.60	143.93	130.83
Average	106.93	116.73	121.10	127.14	
L.S.D		biofertilization	organicfertilizatin	Interaction	
		9.649	9.649	19,298	

Table 3. Effect of organic and biological fertilization and the interaction between them on the average weight of 1000 seeds (gm).

Biofertilization	**Organic fertilization (humic acid) gm.L^{-1}**				**Average**
	0	**3**	**6**	**9**	
control	29.46	30.82	31.50	33.29	31.27
Azotobacter	31.96	33.43	35.09	36.12	34.01
Mycorrhiza	32.27	32.28	35.36	36.14	34.15
Azotobacter + Mycorrhiza	33.26	34.60	35.17	39.27	35.57
average	31.74	32.78	34.28	36.20	
L.S.D		Biofertilization	Organicfertilizatin	Interactin 2.095	
		1.047	1.047	2.095	

Table 4. The effect of biological and organic fertilization and the interaction between them on the yield of one plant (gm.plant^{-1}).

Biofertilization	Organic fertilization (humic acid) gm.L^{-1}				average
	0	3	6	9	
control	14.20	17.54	18.03	23.34	18.28
Azotobacter	20.86	21.97	24.50	25.61	23.23
Mycorrhiza	22.44	23.68	25.25	28.78	25.04
Azotobacter + Mycorrhiza	25.99	27.99	29.74	33.31	29.26
average	20.87	22.79	24.38	27.76	18.28
L.S.D		Biofertilization	organicfertilizatin	Interaction	
		0.797	0.797	1.594	

Table 5. Effect of organic and biological fertilization and the interaction between them on the total yield of mung bean (kg.h^{-1}).

Biofertilization	Organic fertilization (humic acid) gm.L^{-1}				average
	0	3	6	9	
control	1136.27	1403.20	1442.67	1867.47	1462.40
Azotobacter	1668.80	1757.87	1960.00	2049.33	1859.00
Mycorrhiza	1795.20	1894.67	2020.27	2302.67	2003.20
Azotobacter + Mycorrhiza	2079.73	2239.74	2379.53	2665.33	2341.08
average	1670.00	1823.87	1950.62	2221.20	
L.S.D		Biofertilization	organicfertilizatin	Interaction	
		63.791	63.791	127.58	

29.26 g.plant^{-1} compared to the non-fertilization treatment, which amounted to 18.28 g. plant^{-1}, with an increase of 60.06. % The reason for the increase in the yield of one plant is due to the effect of biofertilization in increasing the number of pods, and the weight of seeds as in Tables (12, 14), which was reflected in the yield of a single plant, in addition to the fact that Azotobacter bacteria promote plant growth and help in the absorption of nutrients and increase the building Proteins and amino acids have a positive effect on crop growth by increasing the availability of nutrients and improving soil fertility, which was reflected in the yield (Taleker, 2021).As for the organic fertilization, the humic acid fertilization treatment with a concentration of 9 gm.l^{-1} gave the highest average, as it gave the highest average of 27.76 gm.plant^{-1} compared to the no-fertilization treatment, which amounted to 20.87 gm..plant^{-1}, with an increase of 33.01%. The reason for this is that Organic fertilizers have a major role in improving the physical and chemical properties of the soil, as well as the processing of important nutrients for the plant, which in turn increases the activity of vegetative growth, as well as increasing the number and weight of seeds, as shown in Tables (13,12), which was reflected in the yield of the plant (Hamza, 2018; Al-Ezzi and Al-Obeidi, 2019).

***4. the total yield of the plant (kg.h^{-1})*:** The results of table (5) indicate that there are significant differences in the total yield of the mash plant when biofertilizing with azotobacter and mycorrhizal fungi, as It gave the highest average total plant yield of 2341.08 kg.h^{-1} compared to the no-fertilization treatment, as it reached 1462.40 kg.h^{-1}, with an increase of 60.08%. is due to the increase in total yield as a result of the increase in plant height, number of pods, weight of 1000 seeds, and yield per plant according to tables (3, 12, 13, 14), respectively (Mott *et al.*, 2022). As for the organic fertilization, the fertilization treatment with humic acid at a concentration of 9 gm.l^{-1} gave the highest average, reaching 2221.20 kg.h^{-1} compared to the non-fertilization treatment, which amounted to 1670 kg.h^{-1}, with an increase of 33%. The reason for this is due to the high rate of photosynthesis and the food-making process, and this is due to the positive role of humic acid on the plant (Al-Khafaji, 2015). Positive on increasing the total yield of the plant (Shahryari *et al.*, 2011). In addition to increasing each of the vegetative traits such as plant height, number of branches and leafy area, which led to an increase in the fresh weight of the plant and had a positive effect on the total yield of the plant (Abead *et al.*, 2018).

***Conclusion*:** 1-The effect of biofertilization with azotobacter and mycorrhizal fungi had a significant effect on all studied traits. 2-The organic fertilization with humic acid at a concentration of 9 gm.l^{-1} led to an improvement in the growth characteristics and yield of the mung bean plant. 3-Increasing the effectiveness and activity of azotobacter and mycorrhizal fungi when mixed together, as they work more efficiently than the individual treatments, which led to an increase in growth and yield characteristics.

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Najm Abdullah Juma Al-Zubaidi in conceiving the idea and designing the study, Najm Abdullah Juma Al-Zubaidi A supervised all parts of the manuscript.

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